Plant Archives Vol. 25, Supplement 2, 2025 pp.3228-3232 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.supplement-2.414

UNLOCKING GROWTH POTENTIAL: THE ROLE OF IRON AND ZINC IN DRY DIRECT SEEDED RICE (*ORYZA SATIVA* L.)

Aarthi S.S.T.*, Sudha Rani J.S., Sreedevi B., Sukruth Kumar T.
Department of Agronomy, College of Agriculture, Rajendranagar, PJTAU, Hyderabad- 500030, India
*Corresponding author E-mail: tubatiaarthi@gmail.com
(Date of Receiving : 15-05-2025; Date of Acceptance : 19-07-2025)

ABSTRACT

A field experiment was conducted at Agriculture Research Institute, Rajendranagar, PJTAU, Hyderabad, Telangana during *kharif* season (2025) to study the effect of Iron and Zinc nutrition on growth characteristics of dry direct seeded rice. The experiment was laid out in Randomized block design with 11 treatments of iron and zinc nutrition strategies *viz.* T_1:(control) RDF(150:60:40), T_2:FYM 10t ha^{-1}, T_3: Nutripriming with 0.5% $FeSO_4.7H_2O$, T_4: Nutripriming with 0.5% $ZnSO_4.7H_2O$, T_5:Nutripriming with 0.5% $FeSO_4.7H_2O$ + Nutripriming with 0.5% $ZnSO_4.7H_2O$, T_6: Soil application of Ferrous sulphate 50 kg ha^{-1} $FeSO_4.7H_2O$, T_7:Soil application of zinc sulphate 25 kg ha^{-1} $ZnSO_4.7H_2O$, T_8: Soil application of Ferrous sulphate 50 kg $FeSO_4.7H_2O$+ zinc sulphate 25 kg ha^{-1} $ZnSO_4.7H_2O$, T_9: Foliar application with 0.5% $FeSO_4.7H_2O$ (Foliar application at PI) T_{10}: Foliar application with 0.25 % $ZnSO_4.7H_2O$ (Foliar application at PI), T_{11}: Foliar application with 0.5% $FeSO_4.7H_2O$ + 0.25% $ZnSO_4.7H_2O$ (Foliar application at PI stage), replicated thrice. The results revealed that combined nutripriming with iron and zinc sulphate (T_5) resulted higher plant height (58.10, 86.68, 98.58, 103.99 cm), Dry matter (560.15, 671.75, 860.42, 1091.78 g m^{-2}), Leaf area (506.24, 784.34, 1137.58, 607.94 cm^2 hill^{-1}), Tillers per m^2 (335.10, 376.77, 396.10, 384.10) at active tillering, panicle initiation, flowering, and harvest stages, respectively. Whereas lowest plant height, dry matter, leaf area, tillers m^{-2} were recorded in control plot (RDF).

Keywords: Dry direct seeded rice, nutripriming, foliar spray, iron and zinc nutrition.

Introduction

Rice (*Oryza sativa* L.), one of the most important cereal grains for human nutrition especially in Asia and Africa, ranks as a superior staple food crop worldwide. More than its nutritional value, it is a cultural icon, an economic powerhouse and the heart of countless culinary traditions. In the world, about 165 million hectares of rice- cultivated area was there and produced a total production of from 776 million tons (Antonino Spanu *et al.*, 2024). The country has more than 70% of the Indian population contributing to 40% in total food grain production hence, plays a centre stage role when it comes to providing security pertaining both consumption and livelihood semi class.

Traditional transplanted rice requires1500 mm of water. A study by Bouman and Tuong (2001) suggests that 3000-500 liters of water is necessary per kg yield of rice under irrigated conditions. These days, grotesque paucity of water threatens the sustainability of irrigated rice ecosystems. Because rice is a water-consuming crop and with on-going water shortage problem in many of the rice-growing areas and adverse effects associated with puddle transplanted rice cultivation like soil degradation, methane emissions an effort has been made to search for production systems that require less amount of irrigation water to produce more amounts of paddy grain (Farooq *et al.*, 2011). New agronomic practices need to be developed and standardized to cope up the water scarcity for rice cultivation.

Direct seeded rice (DSR) pertains to the practice of establishing the crop from seeds sown in the field rather than by transplanting seedlings from the nursery (Farooq *et al.*, 2011). Direct seeding avoids three basic operations, namely, puddling (a process where soil is compacted to reduce water seepage), transplanting and maintaining standing water (Joshi *et al.,* 2013). It will considerably put down the labor demand, which found as one of the most expensive in rice agriculture.

Micronutrients deficiencies in cereal crops especially rice, due to depletion of soil micronutrient reserves have emerged as a major concern causing malnutrition and various other disorders mainly in developing countries micronutrient deficits are a problem in DSR, and imbalance of these nutrients is caused by improperly applied and unbalanced N fertilizer. Most rice consuming areas are endemic to iron and zinc deficiencies. Globally, more than 30% of soils are low in plant-available Zn (Hacisalihoglu and Kochian, 2003). Fouly (1983) found that the availability of micronutrients such as Fe and Zn is much affected by pH, $CaCO_3$ content and soil texture.

For reducing the yield losses and micronutrients deficiency (Johnson *et al.,* 2005), ferti-fortification is a target specific efficient approach to achieve good grain quality in addition higher net returns from resource poor soils. Application of nutrient in combination led to significant increase in concentration of iron and zinc during maturation conditions both with the grain as well with straw (Jin Z, Minyan *et al*., 2008).

Materials and Methods

A field experiment was conducted at ARI, Rajendranagar, PJTAU, Hyderabad, Telangana during *kharif* season (2025) at 17°19'N and 78° 23' E at an altitude of 542.6 m above mean sea level. The field experiment site had an even topography with moderate slope and good drainage. A composite representative soil sample was collected from the experimental field prior to start of the experimentation and analysed for physico-chemical properties. The soil was sandy clay loam with alkaline pH (8.28), EC (0.33ds/m). Soil had 208.5 kg/ha available N (Subbiah and Asija, 1956), 26.3 kg/ha available P (Olsen *et al.,* 1954), 382.2 kg/ha available K (Jackson, 1967), 0.57% organic carbon (Walkley and Black, 1934) and iron (4.1 ppm) and zinc (0.4 ppm) (Lindsay and Norvell, 1978. The rice–rice cropping system has been adopted continuously in the experimental area for the last 3 years. Research was laid out in Randomized block design with the 11 following treatments T_1:(control) RDF(150:60:40), T_2:FYM 10t/ha, T_3: Nutripriming with 0.5% $FeSO_4.7H_2O$, T_4: Nutripriming with 0.5% $ZnSO_4.7H_2O$, T_5: Nutripriming with 0.5% $FeSO_4.7H_2O$ + Nutripriming with 0.5% $ZnSO_4.7H_2O$, T_6: Soil application of Ferrous sulphate 50 kg ha^{-1} $FeSO_4.7H_2O$, T_7:Soil application of zinc sulphate 25 kg ha^{-1} $ZnSO_4.7H_2O$, T_8: Soil application of Ferrous sulphate 50 kg ha^{-1} $FeSO_4.7H_2O$+ zinc sulphate 25 kg ha^{-1} $ZnSO_4.7H_2O$, T_9: Foliar application with 0.5% $FeSO_4.7H_2O$ (Foliar application at PI) T_{10}: Foliar application with 0.25 % $ZnSO_4.7H_2O$ (Foliar application at PI), T_{11}: Foliar application with 0.5% $FeSO_4.7H_2O$ + 0.25% $ZnSO_4.7H_2O$ (Foliar application at PI stage). In the treatments of nutripriming seeds were soaked in 0.5% solution of iron and zinc sulphate individually and in combination. Basal application is done before sowing of seeds with 50kg/ha iron sulphate and 25kg/ha zinc sulphate and in combination. In other treatments, solutions of 0.5% and 0.25% concentration of iron sulphate and zinc sulphate respectively were applied through foliar application individually and in combination at panicle initiation stage. The treatments were randomly allocated to different plots using random number table of Fisher and Yates (1963), in a randomized block design with 3 replicates.

Recommended doses of nitrogen, phosphorus and potassium (150:60:40 kg/ha) were applied through urea, DAP, MOP as a basal and two split of nitrogen in all the treatments. Iron and zinc were applied through iron sulphate (heptahydrate) and zinc sulphate (heptahydrate) respectively, as per the treatments. All the standard recommended agronomic practices, except those in treatments, were followed to grow the rice crop.

Telangana Sona (RNR-15084) rice variety was sown on July 10, 2025 and harvested on November 2, 2025.From each treatment plot five random plants were selected for non-destructive observations (plant height, tillers m^{-2}). Plant height (cm) of direct seeded rice was measured from the ground to the tip of the top most leaf (or) panicle. Numbers of tillers were recorded by counting from randomly selected plants. Plant samples from border row were harvested to ground level for estimation of dry matter at different growth stages. These sampled plants were sun-dried for 2–3 days and later oven-dried at 60±2°C for 24 hrs and dry weight (g m^{-2}) was recorded at active tillering, panicle initiation, flowering and harvesting stage. For estimation of leaf area LI-COR M automatic leaf area meter is used.

The experimental data was statistically analysed by applying "Analysis of Variance" technique for randomized block design. Standard error of mean (SEm±) and Critical difference (CD) at 5% significance level was worked out for each observation as per the method suggested by (Gomez and Gomez, 1984).

Table 1 : Physical and chemical properties of experimental soil (0-15 cm)

Particulars	Values	Method of analysis
A. Physical properties		
Sand (%)	64.52	Bouyoucus hydrometer method (Piper, 1966)
Silt (%)	14.02	
Clay (%)	21.46	
Soil texture	Sandy clay loam	
Bulk density (g cm^{-3})	1.42	Core sampler method (Blake,1965)
B. Chemical properties		
Soil pH (1:2.5 soil-water suspension)	8.28	pH meter (Jackson, 1967)
EC (dS m^{-1} at 25°C)	0.33	EC meter (Jackson, 1967)
Organic carbon (%)	0.57	Chromic acid wet digestion method (Walkley and Black's, 1934)
Available Nitrogen (kg N ha^{-1})	208.5	Alkaline permanganate method using KELPLUS SUPRA LX – analyser (Subbaiah and Asija, 1956)
Available Phosphorus (kg P ha^{-1})	26.3	Olsen's method for extraction and Ascorbic acid method for estimation by Spectrophotometer (Olsen's *et al.,* 1954)
Available Potassium (kg K ha^{-1})	382.2	Neutral normal ammonium acetate method using ELICO CL361 Flame photometer (Jackson, 1967)
Available Zn (ppm)	0.4	DTPA extract method using atomic absorption spectrophotometer. (Lindsay and Norvell, 1978)
Available Fe (ppm)	4.1	DTPA extract method using atomic absorption spectrophotometer. (Lindsay and Norvell, 1978)

Results and Discussion

Plant height

Direct seeded rice is a highly responsive to micronutrient application. So, iron and zinc nutrition influenced the growth parameters of direct seeded rice. It is clearly evident from the data (Table 3) that iron and zinc application increased plant height at all the growth stages of crop growth period. At active tillering, panicle initiation, flowering, and harvest stages plant height was significantly higher in T_5 : Nutripriming with 0.5% $FeSO_4.7H_2O$ + Nutripriming with 0.5% $ZnSO_4.7H_2O$ (58.10, 86.68, 98.58, 103.99 cm) respectively, however it was on par with T_8:Soil application of Ferrous sulphate 50 kg ha^{-1} $FeSO_4.7H_2O$+ zinc sulphate 25 kg ha^{-1} $ZnSO_4.7H_2O$. The lowest plant height was recorded with T_1 (control).

The plant height increased significantly with combined nutripriming or soil application of iron and zinc along with recommended dose of fertilizers. Both T5 and T8 were on par at all the stages. This might be due to availability of nutrients in adequate amount in balanced proportion resulting in improved crop establishment with better root development. Iron and zinc accelerate enzymatic activity in the plants and also helps in increasing in internodal length. Also, nutripriming of seeds enhance germination, seedling vigour, and overall plant growth. The results were in close vicinity with findings of Abhishek *et al.* (2023), Malamasuri *et al.* (2017).

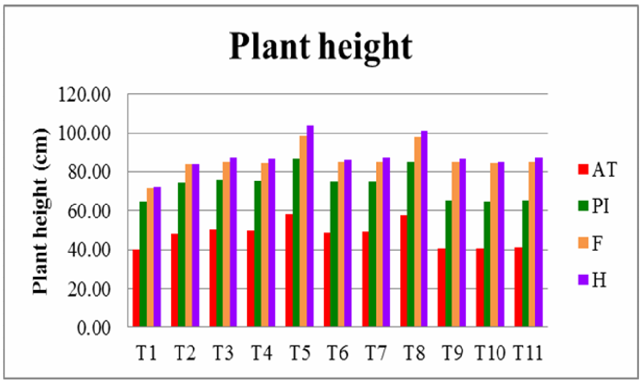

Fig. 1 : Plant height (cm) of direct seeded rice as influenced by iron and zinc nutrition

Dry matter accumulation (g/m^2)

In general, dry matter increased substantially with the advancement of crop age (Fig.1). The highest dry-matter accumulation was recorded at harvesting stage. Among different iron and zinc nutrition strategies highest dry matter (g/m^2) was recorded with T_5 : Nutripriming with 0.5% $FeSO_4.7H_2O$ + Nutripriming with 0.5% $ZnSO_4.7H_2O$ at all stages (560.15, 671.75, 860.42, 1091.78 g/m^2) however it was on par with T_8: Soil application of Ferrous sulphate 50 kg ha^{-1} $FeSO_4.7H_2O$+ zinc sulphate 25kg ha^{-1} $ZnSO_4.7H_2O$. The lowest dry matter yield was recorded with control plot (T_1). This indicates that the combined application helped towards balanced availability of nutrients throughout the crop growth period. The enhanced availability of nutrients especially iron and zinc, under direct seeded rice might have led to better accumulation of photosynthates in the form of dry matter. The results were in close vicinity with findings of (Rakesh *et al.,* 2012) and (Meena *et al.,* 2018).

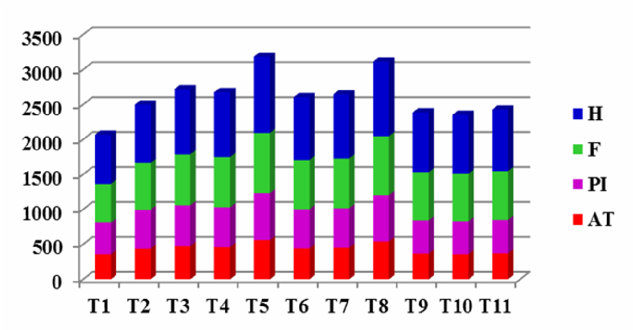

Fig. 2 : Dry matter of direct seeded rice as influenced by iron and zinc nutrition.

Leaf area (cm^2 $hill^{-1}$)

Leaf area is crucial for plant function and is used to assess plant health, growth, and productivity. It is a key factor in photosynthesis, transpiration, and overall plant development. Larger leaf area development aids in more interception of light leading to higher dry matter production. Leaf area is measured at active tillering, panicle initiation, flowering and at harvesting stage. Maximum leaf expansion is seen at flowering stage gradually all the photosynthates produced transferred to sink i.e. grains and during harvest stage leaf area is reduced. At all stages significantly highest leaf area is seen in T_5 : Nutripriming with 0.5% $FeSO_4.7H_2O$ + Nutripriming with 0.5% $ZnSO_4.7H_2O$ (506.24, 784.34, 1137.58, 607.94 cm^2 $hill^{-1}$) however it was on par with T_8: Soil application of Ferrous sulphate 50 kg ha^{-1} $FeSO_4.7H_2O$+ zinc sulphate 25 kg ha^{-1} $ZnSO_4.7H_2O$. Lowest leaf area is observed in T_1 control plot. The results were in close vicinity with findings of (Mondal *et al.,*2020).

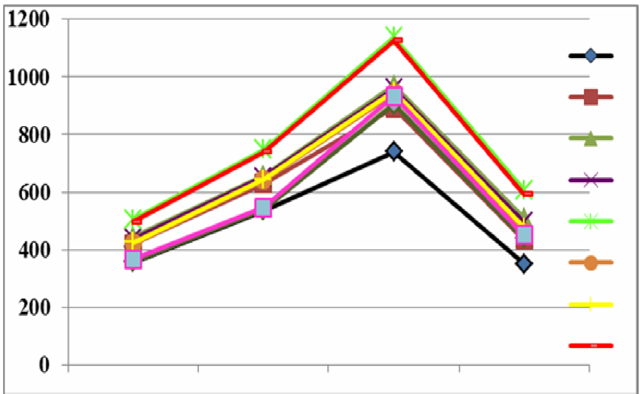

Fig. 3: Leaf area (cm^2 $hill^{-1}$) of direct seeded rice as influenced by iron and zinc nutrition Tillers per m^2

Tillers are specialized branches that develop from the base of the plant and play a crucial role in determining yield. They are essential for producing panicles and directly influence the number of grains produced. They also contribute to the dry matter production there by the increasing straw yield. Among different treatments significantly highest number of tiller per m^2 were observed in T_5 : Nutripriming with 0.5% $FeSO_4.7H_2O$ + Nutripriming with 0.5% $ZnSO_4.7H_2O$ (335.10, 376.77, 396.10, 384.10) however it was on par with T_8: Soil application of Ferrous sulphate 50 kg ha^{-1} $FeSO_4.7H_2O$+ zinc sulphate 25 kg ha^{-1} $ZnSO_4.7H_2O$. Lowest tillers per m^2 were observed in T_1 control plot. This might be due to improved metabolic activity with micronutrients that enhanced the floral primordia development in many tillers. The results were in close vicinity with findings of Sridhara *et al*. (2012), Gill and Walia. (2013).

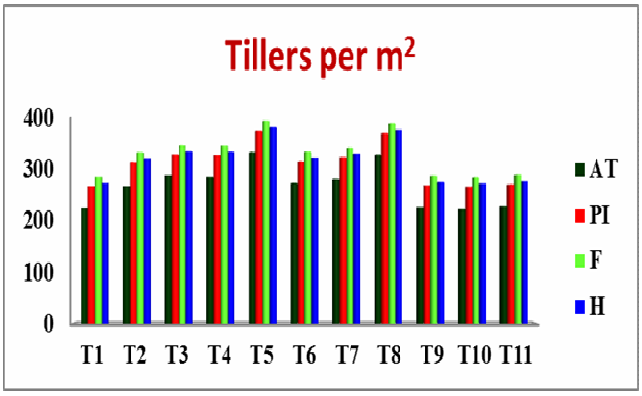

Fig. 4 : Tillers per m^2 of direct seeded rice as influenced by iron and zinc nutrition

Conclusion

The results of the field experiment highlight the critical role of iron and zinc nutrition in promoting the early growth and vigour of direct seeded rice. Among the treatments, seed nutripriming with 0.5% $FeSO_4.7H_2O$ + 0.5% $ZnSO_4.7H_2O$ along with recommended fertilizer application (150:60:40 NPK kg/ha) or soil application of ferrous sulphate 50 kg ha^{-1} $FeSO_4.7H_2O$+zinc sulphate 25 kg ha^{-1} $ZnSO_4.7H_2O$, emerged as the most effective strategy for enhancing key growth traits. This nutrient management approach holds promise for improving crop establishment and overall performance in direct seeded rice systems.

References

Bhanvadia, A.S., Yadav, S.L., Singh, D.P. and Birla, D. (2023). Response of direct seeded rice to iron and zinc fertilization strategies under Middle Gujarat conditions. *International Journal* of *Plant & Soil Science,* **35**, 1116-1124.

Blake, G.R. (1965). Bulk density, Methods of soil analysis, Part 1 physical and mineralogical properties, including statistics of measurement and sampling, **9**, 374-390.

Bouman, B.A.M. and Tuong, T.P. (2001). Field water management to save water and increase its productivity in irrigated lowland rice. Agricultural water management, **49**(1), 11-30.

Bouyoucos, G.J. (1927). The hydrometer as a new method for mechanical analysis of soils. *Soil Science*, **23**, 343-353.

Farooq, M.K.H.M., Siddique, K.H., Rehman, H., Aziz, T., Lee, D.J. and Wahid, A. (2011). Rice direct seeding, experiences, challenges and opportunities. *Soil and tillage research,* **111**(2), 87-98.

Gill, J.S. and Walia, S.S. (2014). Effect of foliar application of iron, zinc and manganese on direct seeded aromatic rice (*Oryza sativa*). *Indian Journal of Agronomy,* **59**(1), 80-85.

Goverdhan, M. (2017). Influence of iron and zinc management on dry matter production and nutrient removal by rice (*Oryza sativa* L.) and soil fertility status under aerobic cultivation. *Chemical Science Review and Letters,* **6**(24), 2627-2635.

Hacisalihoglu, G. and Kochian, L.V. (2003). How do some plants tolerate low levels of soil zinc? Mechanisms of zinc efficiency in crop plants. *New phytologist,* **159**(2), 341-350.

Jackson, M.L. (1973). Soil Chemical Analysis. Prentice Hall Pvt. Ltd., New Delhi

Jin, Z., Minyan, W., Lianghuan, W., Jiangguo, W. and Chunhai, S. (2008). Impacts of combination of foliar iron and boron application on iron biofortification and nutritional quality of rice grain. *Journal of Plant Nutrition*, **31**(9), 1599-1611.

Johnson, S.E., Lauren, J.G., Welch, R.M. and Duxbury, J.M. (2005). A comparison of the effects of micronutrient seed priming and soil fertilization on the mineral nutrition of chickpea (*Cicer arietinum*), lentil (*Lens culinaris*), rice (*Oryza sativa*) and wheat (*Triticum aestivum*) in Nepal. *Experimental Agriculture*, **41**(4), 427-448.

Joshi, E., Kumar, D., Lal, B., Nepalia, V., Gautam, P. and Vyas, A.K. (2013). Management of direct seeded rice for enhanced resource-use efficiency. *Plant Knowledge Journal,* **2**(3), 119-134.

Lindsay, W.L and Norvell, W.A. (1978). Development of DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of America Journal*, **43**, 421-428.

Meena, R.P., Prasad, S.K. and Singh, M.K. (2019). Effect of nitrogen and zinc application on growth, grain quality and nutrient indices of direct seeded rice (*Oryza sativa* L). *Annals of Agricultural Research,* **40**(1), 1-8.

Mondal, B. and Pramanik, K. (2020). Effect of irrigation regimes and method of zinc application on growth and yield attribute of aerobic rice in lateritic soil. *Plant Archives* (09725210), 20(1).

Olsen, S.R., Cole, C.V., Watanabe, F.S and Dean, L.A. (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate, Circular U.S. Department of Agriculture. 939.

Rakesh, D. (2012). Response of aerobic rice (*Oryza sativa* L.) To varying fertility levels in relation to iron application (doctoral dissertation, acharya ng ranga agricultural university rajendranagar, hyderabad).

Spanu, A., Langasco, I., Mara, A. and Sanna, G. (2024). Sprinkler irrigation, An efficient and eco-friendly approach to produce safe rice. *Journal of Agriculture and Food Research,* **17**, 101254.

Sridhara, C.J., Shashidhar, H.E., Gurumurthy, K.T., Ramachandrappa, B.K. (2012). Effect of genotypes and method of establishment on root traits, growth and yield of aerobic rice. *Agricultural Science Digest,* **32**(1), 13–17.

Subbaiah, B.V. and Asija, C.L. (1956). A rapid procedure for the estimation of available nitrogen in soils. *Current Science*, **25**, 32.

Walkley, A. and Black, I.A. (1934). An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Sci*., **37**, 29-38.